Metabolic evaluation: who, when and how often

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Abstract: PURPOSE OF REVIEW To summarize recommendations of the guidelines of the American Urological Association and European Association of Urology, and our opinion on which urinary tract stone disease patients should be metabolically evaluated at which moment and how often. RECENT FINDINGS A standard metabolic evaluation should be performed in all stone formers to prevent recurrent disease. This includes a medical and lifestyle history, physical examination, basic urine and blood analysis, radiological examination and stone analysis. The latter should already be performed during surgery, especially when only a couple of fragments are sent for analysis. Supplementary, performing a 24-h urine analysis should be supported in all patients to understand the lithogenic process that will guide the according follow-up. When risk factors are found, an extended individualized metabolic evaluation should be performed to exclude underlying metabolic diseases and to start stone-specific recurrence prevention. SUMMARY Urologists should be trained in perioperative stone characterization, because it contains information of urinary environment at the times of stone formation and growth. The extensiveness and frequency of metabolic work-up and follow-up of stone formers should be tailored to the type of stone, severity of the disease, patient's comorbidities and medications.

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Metabolic evaluation: who, when and how often

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Purpose of review
To summarize recommendations of the guidelines of the American Urological Association and European Association of Urology, and our opinion on which urinary tract stone disease patients should be metabolically evaluated at which moment and how often.

Recent findings
A standard metabolic evaluation should be performed in all stone formers to prevent recurrent disease. This includes a medical and lifestyle history, physical examination, basic urine and blood analysis, radiological examination and stone analysis. The latter should already be performed during surgery, especially when only a couple of fragments are sent for analysis. Supplementary, performing a 24-h urine analysis should be supported in all patients to understand the lithogenic process that will guide the according follow-up. When risk factors are found, an extended individualized metabolic evaluation should be performed to exclude underlying metabolic diseases and to start stone-specific recurrence prevention.

Summary
Urologists should be trained in perioperative stone characterization, because it contains information of urinary environment at the times of stone formation and growth. The extensiveness and frequency of metabolic work-up and follow-up of stone formers should be tailored to the type of stone, severity of the disease, patient's comorbidities and medications.

Keywords
metabolic evaluation, prevention, recurrence, stone analysis, urinary stone disease

INTRODUCTION

The worldwide prevalence of kidney stones has been increasing over the past decades, with a triplication in several countries since the First World War [1–3]. This increase is mainly caused by a modification in dietary habits with a decreased intake of fibres and alkali-rich food (such as vegetables and fruits), and an increased intake of refined sugar, fat, animal proteins and sodium [4,5]. Other causes of stone formation include congenital or acquired disorders causing metabolic disorders. To discover these underlying causes and diseases in stone formers, it is of utmost importance to perform a metabolic evaluation to tailor an adequate therapy [6].

There is, however, a lack of consensus which patients should be considered for an in-depth metabolic investigation. It also remains unclear when, how and how often patients should be evaluated. We aim to answer these questions based on the current guidelines of the American Urological Association (AUA) and European Association of Urology (EAU), and our opinion.

STANDARD EVALUATION

The AUA and EAU guidelines state that all first-time stone formers should be evaluated with a medical and dietary history, a basic biochemical work-up of urine and blood, and a radiological evaluation. A reliable stone analysis by infrared spectroscopy or X-ray diffraction should be performed in all first-time stone formers following the EAU guidelines and at least once following the AUA guidelines [7,8].

History and physical examination

Following AUA and EAU guidelines, an anamnesis targeting personal and medical history, diet and medication, and physical examination should be systematically performed in all stone formers to understand the lithogenic process and to interpret the urinalysis [7,9].

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KEY POINTS

- All first-time stone formers should be evaluated with a medical and dietary history, a basic biochemical work-up of urine and blood (including glycaemia), a radiological evaluation and stone analysis.
- Stone characterization should already be performed during surgical treatment.
- A basic 24-h and a fresh early morning urinalysis should be considered in all stone formers.
- An extensive patient-specific evaluation should be individually determined.
- The frequency of metabolic work-up and follow-up of stone formers should be tailored to the type of stone, severity of the disease, patient comorbidities and medications.

Lifestyle factors and medical conditions may predispose to stone disease and may make some additional examinations redundant. Insufficient diuresis is a frequent risk factor that might be particularly pronounced in patients with low fluid intake or high extrarenal fluid losses (e.g. athletes, teachers, drivers or people living or working in hot environments) [10,11,12▪]. Further, it involves questioning about age of first stone diagnosis [13], medical history (e.g. urinary tract infections, diarrhoea, inflammatory bowel disease, cystic fibrosis, chronic pancreatitis, gout, diabetes, renal tubular acidosis type 1, hyperparathyroidism, sarcoidosis, Sjögren's syndrome, bone disease) [14,15] and surgical history (e.g. fracture, bariatric surgery, bowel resection) [16–18], and also medication causing metabolic disorders leading to stone formation (e.g. protease inhibitors, carbonic anhydrase inhibitors, supplements of vitamins or calcium) or inducing stones (e.g. amoxicillin, atazanavir, ceftriaxone, ciprofloxacin, sulfamethoxazole) [19▪]. Each of these pathologies or medications is associated with specific types of stones and should ring a bell to prevent or decrease stone recurrence (Table 1).

Dietary habits are related to kidney stone formation as well [21]. These habits can be evaluated with a food intake registration of 3 days. Another option is using a food frequency questionnaire to obtain information of frequency and portion size over 1 week [22]. This survey evaluates the intake of fluid (amount and type of beverages), calcium, sodium, animal proteins, sugar, purines and oxalate. In general, high fluid intake decreases the risk of recurrent nephrolithiasis by reducing crystallization [23]. A rich calcium diet can lead to hypercalciuria, whereas a low calcium intake increases the intestinal absorption and renal excretion of oxalate [24]. Foods high in sodium decrease the renal re-absorption of calcium, phosphate, oxalate and uric acid [25]. High-protein foods stimulate the endogenous oxalate and uric acid synthesis, and induce an acid overload that decreases renal re-absorption of calcium and excretion of citrate. This metabolic acidosis also decreases urinary pH, which facilitates crystallization of uric acid [26,27▪]. Hyperglycaemia results in reduced ammonium buffer excretion and a low urine pH, leading to uric acid stone formation [28]. In practice, reducing soft drink intake lowers the risk of urolithiasis formation in patients with high baseline soft drink consumption [29]. In summary, patients with recurrent calcium oxalate stones and hypercalciuria should be specifically screened for any excessive protein and/or salt intake, and also excessive calcium intake [24,30,31]. In case of hyperuricosuria or disorders linked to the uric acid synthetic pathway, excessive purine and fructose intake should be excluded [32].

During physical examination, obesity, hypertension and scars related to surgery should not be overlooked [33,34]. All patients should be measured and weighed, because overweight shows clear alterations in metabolic urinary profiles that are associated with increased overall risk of stone formation [35].

Basic urine and blood analysis

Each patient with urolithiasis needs a succinct urine and blood analysis to identify biochemical causes of stone formation [36]. Both AUA and EAU guidelines recommend dipstick and microscopic evaluation to assess urine pH, indicators of infection and to identify crystals pathognomonic of stone type [7,9].

Following EAU guidelines, blood analysis includes at least creatinine, uric acid, (ionized) calcium, sodium, potassium, blood cell count and C-reactive protein [8]. In contrast to AUA guidelines, they do not recommend systematically analyzing chloride and bicarbonate [7]. They rather recommend measuring serum bicarbonate when urinary pH levels are constantly above 5.8. When bicarbonate is low, renal tubular acidosis may be identified, leading to calcium phosphate stone formation. High urine pH in combination with the presence of urease-producing bacteria substantiates the suspicion of struvite stones [8]. Surprisingly, glycaemia is not mentioned either in the EAU or in the AUA guidelines, even though urolithiasis may occur as a first presentation of diabetes mellitus [37].

Medical imaging examinations

The EAU and AUA guidelines both recommend imaging studies to quantify stone burden [7,8]. This

Table 1. Morphological classification of urinary calculi

Type	Subtype	Composition	Frequency (%)[a]	Surface	Section	Cause
I	Ia	Whewellite	45	Brown; smooth, mammillary or mulberry-shaped; frequent umbilication	Brown; compact, concentric structure, radial crystallization	Diet hyperoxaluria, medullary sponge kidney, Randall plaques
	Ib	Whewellite	7	Beige to dark brown; mammillary and rough	Dark brown; compact with some gaps, unorganized	Hyperoxaluria, stasis, crystalline conversion
	Ic	Whewellite	0.4	Cream to light brown; smooth or granular	Beige; compact, finely granular, unorganized	Primary hyperoxaluria
	Id	Whewellite	1.6	Pale brown; smooth	Beige; compact, microcrystalline structure, thin concentric layers	Malformative uropathy, stasis, multiple stones
	Ie	Whewellite	0.5	Beige; mammillary or granular	Beige; powdery, unorganized	Enteric hyperoxaluria, short bowel
II	IIa	Weddellite	30	Yellowish-brown; spiculate, entanglement of bipyramidal crystals	Yellowish-brown; crystalline, radial crystallization	Hypercalciuria
	IIb	Weddellite ± whewellite	22	Yellowish-brown; spiculate, entangled pyramidal crystals, blunt edges	Yellowish-brown; compact, crystalline, unorganized	Hypercalciuria ± hyperoxaluria, stasis, crystalline conversion
	IIc	Weddellite	0.1	Grey-beige to dark yellow-brown; rough, microcrystalline	Dark yellow-brown; peripheral diffuse concentric, core loose unorganized	Hypercalciuria, malformative uropathy stasis, multiple stones
III	IIIa	Anhydrous uric acid	2	Ochar or grey-beige; homogeneous, crystalline, smooth or slightly embossed	Ocher; compact concentric structure, radial crystallization	Hyperuricosuria, acid pH, stasis
	IIIb	Dihydrate uric acid ± anhydrous	9	Whitish to brownish-red; heterogeneous, locally crystalline, rough or porous	Orange; compact or loosely crystalline, unorganized structure, porous areas	Renal ammoniagenesis defect, hyperuricemia, hyperuricosuria, gout, diabetes mellitus, metabolic syndrome, diarrhea, candidiasis, myelo- and lymphoproliferative diseases
	IIIc	Various urates	1.1	Whitish to grey-brown; heterogeneous, rough, locally porous, microcrystalline	Grey-brown; compact, microcrystalline, unorganized	Hyperuricosuria, alkaline pH (iatrogenic, UTI)
	IIId	Ammonium urate	0.2	Greyish to brown; heterogeneous, microcrystalline, rough and extensively porous	Grey-brown; heterogeneous, loose concentric layers (thick brown/thin beige), locally porous	Hyperuricosuria, renal or urinary hyperammoniagenesis, phosphorus deficiency, digestive alkali loss (chronic infectious diarrhoea, laxative abuse), malnutrition, anorexia nervosa
IV	IVa1	Carbapatite	30	Whitish to beige; homogeneous, crystalline, rough, finely embossed	Beige; homogeneous, microcrystalline, crumbly ± concentric structure	UTI, hypercalciuria with incomplete renal tubular acidosis, primary hyperparathyroidism, secondary renal tubular acidosis (e.g. acetazolamide)

Table 1 (*Continued*)

Type	Subtype	Composition	Frequency (%)[a]	Surface	Section	Cause
	IVa2	Carbapatite	1.6	Brown-yellow; heterogeneous embossed, crystalline, glazed, irregular shape	Heterogeneous concentric foliated. Thick brown-yellow layers and thin microcrystalline beige layers	Primary (e.g. Albright) or acquired (e.g. Sjögren's) distal renal tubular acidosis, UTI, medullary sponge kidney
	IVb	Carbapatite ± struvite	6	Whitish to brown; heterogeneous, both rough and embossed	Heterogeneous concentric with thick whitish and thin brown-yellow layers	Primary hyperparathyroidism, hypercalciuria and hyperphosphaturia, UTI
	IVc	Struvite	2.5	White; homogeneous, crystalline, amalgate crystals with blunt edges	White; loose, radial crystallization, sometimes diffuse concentric organization	UTI
	IVd	Brushite	1.7	Whitish to beige. Homogeneous, crystalline, finely rough or dappled, slightly translucent	White-beige; Compact concentric layers with radial crystallization	Hypercalciuria and hyperphosphaturia, primary hyperparathyroidism, medullary sponge kidney, sarcoidosis, phosphate diabetes, distal renal tubular acidosis
V	Va	Cystine	1.1	Brown-yellow; homogeneous, crystalline, granular or embossed, waxy aspect	Yellow-pale brown; homogeneous, unorganized, diffuse radial crystallization	Cystinuria
	Vb	Cystine	0.2	White, beige, brown-yellow; homogeneous, microcrystalline, smooth	Yellow-brown; homogeneous, compact, whitish thin concentric layers in periphery, unorganized core	Cystinuria with inadequate therapy, malformative uropathy, stasis, multiple stones
VI	VIa	Proteins	0.7	White to pale brown; soft, homogeneous, smooth, unorganized, translucent	White to pale brown; homogeneous, unorganized, foci of secondary mineralization	Chronic pyelonephritis
	VIb	Proteins + medication or metabolic derivatives	5	Brown to black; heterogeneous, irregularly rough, locally scaled	Brown blended with colour of associated components; heterogeneous, slightly organized	Proteinuria, haematuria, drugs
	VIc	Proteins and whewellite	0.1	Brown to black; homogeneous, smooth with clefts and scales	Yellow-brown; homogeneous, unorganized, loose, brown or heterogeneous with brown proteic shield surrounding a loose core	End-stage renal failure, haemodialysis with calcium/vitamin D supplements
VII		Miscellaneous				

UTI, urinary tract infection.
[a]Cumulative for pure and mixed form.
Adapted from [20].

can be performed with ultrasound, plain abdominal radiograph and (low-dose) computed tomography (CT) that disclose information about stone characteristics, including the number, size, morphology and radiopacity.

Preoperatively, stone composition can be estimated based on radiological imaging. On plain abdominal radiograph, weddellite stones are characterized by blur contours and intermediate density, whereas cystine stones have blunt contours and a low density. Whewellite and brushite stones have a high density with smooth and speculated contours, respectively. Stones mainly composed of uric acid, ammonium urate, xanthine or 2.8-dihydroxyadenine are radiolucent on plain abdominal imaging. Drug stones and protein matrix stones are also radiolucent on CT [38].

With CT imaging, Hounsfield unit density can be used to characterize differences in radiodensities among urinary stones and can be helpful in planning alternative treatment for patients with a likelihood of a poor outcome from shock wave lithotripsy [39–42]. Dual-energy CT is able to differentiate uric acid, cystine, struvite and mixed stones from other types of stones [43,44].

In our opinion, every stone former should have at least once a CT urography to reflect the anatomy of the urinary tract and to reveal even small or subtle collecting system abnormalities [45]. Nephrocalcinosis and anatomical anomalies favouring stones like medullary sponge kidney, calyceal diverticula and horseshoe kidney can be differentiated with this examination [46–49].

Stone examination

Following EAU guidelines, every and each stone or fragments of a stone should be send for determination of composition by X-ray diffraction or infrared spectroscopy, because stone composition is a cornerstone for further diagnostic and management decisions [9,50–52]. In contrast, AUA guidelines state that a stone analysis should be performed at least once when a stone is available, because it may help direct preventive measures [7].

Stone characterization should already be performed during endoscopic surgical treatment, because there is a variability in the reporting of stones among laboratories [53]. Surface characterization is based on colour, size, pattern and aspect of crystals, and also on morphological particularities (e.g. papillary umbilication with a Randall's plaque). During lithotripsy, internal features like concentric, radial, compact or loose structure, and the organization of alternating layers can help determining the stone type (Table 1 and Fig. 1). Other important marks for understanding the lithogenic process are the localization of the stone (e.g. diverticulum, bladder), its mounting surface and its metabolic activity (e.g. greyish layer of crystals covering the stone surface indicating recent episode of

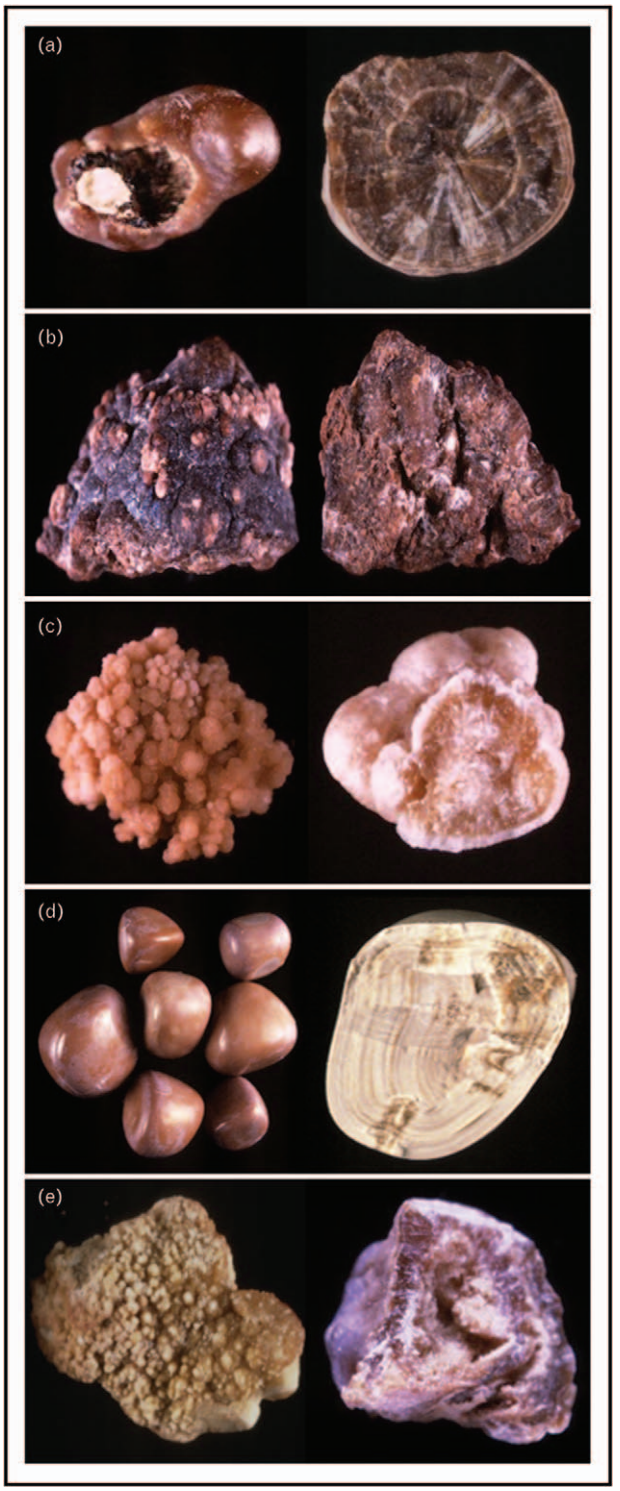

FIGURE 1. Stone classification from type Ia to VI (surface and section), according to Daudon *et al.*

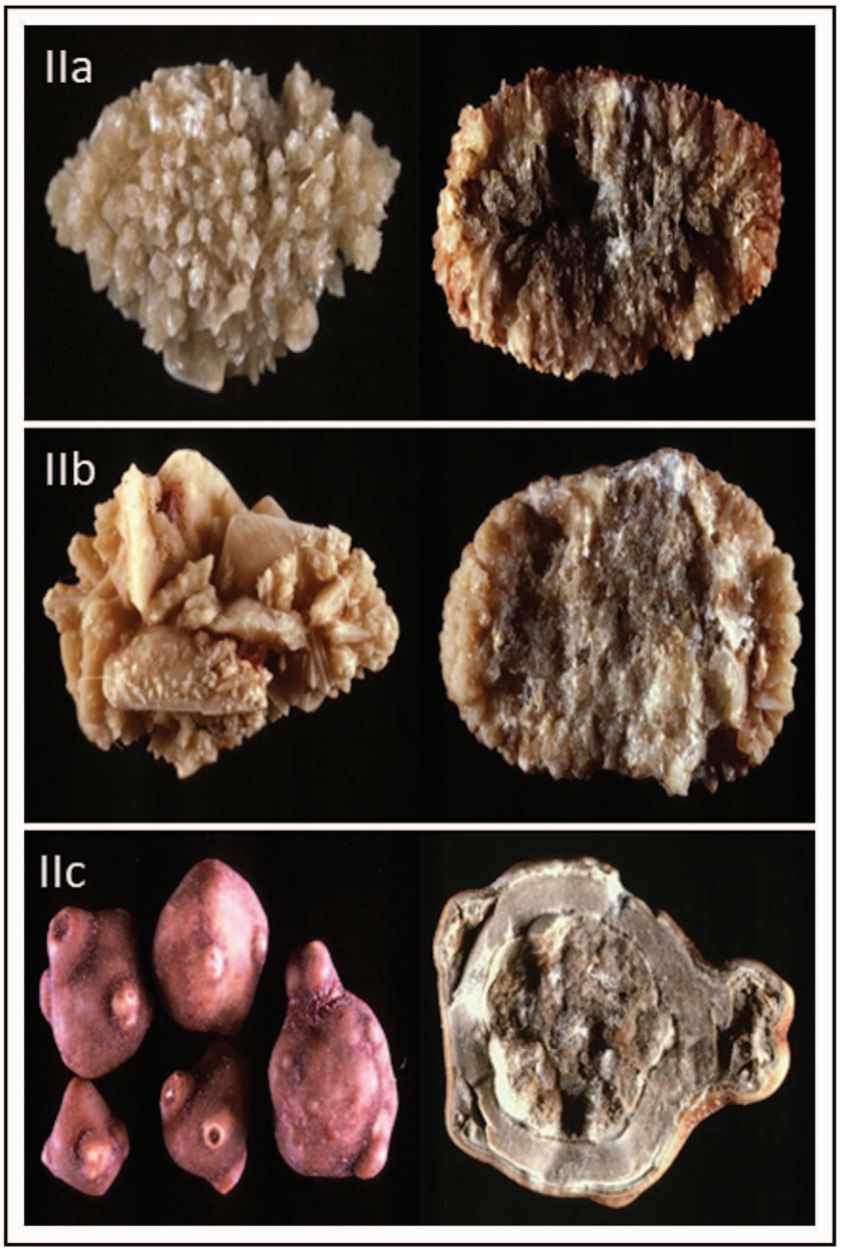

FIGURE 1. (*Continued*).

hyperoxaluria) [20]. Considering all these parameters will help in the early detection of certain diseases, especially when blood and urine analyses are normal [54].

Calcium oxalate monohydrate or whewellite stones (type I) are associated with hyperoxaluria. This can be caused by extensive oxalate intake (e.g. cacao, dark chocolate, pepper, spinach, rhubarb, tea leaves, star fruit, sorrel, beets) or inadequately low fluid intake, inflammatory bowel diseases, short bowel syndrome or genetic disorders. Noticing subtype Ic stones should raise a red flag because they are pathognomonic for primary hyperoxaluria and may lead to renal failure as early as infancy. A high proportion of calcium oxalate stones are a mixture of whewellite and weddellite (type II) stones. The latter are associated with hypercalciuria. Hyperuricosuria can provoke type III stones. They are subdivided in uric acid stones (type IIIa and IIIb) and urate stones (type IIIc and IIId). Patients diagnosed with type IIId stones should be suspected for chronic diarrhoea with phosphorus deficiency and malnutrition. Type IVa carbonate apatite (carbapatite) stones are frequently found in patients with chronic urinary tract infections. Other causes include renal tubular acidosis (type IVa2) or primary

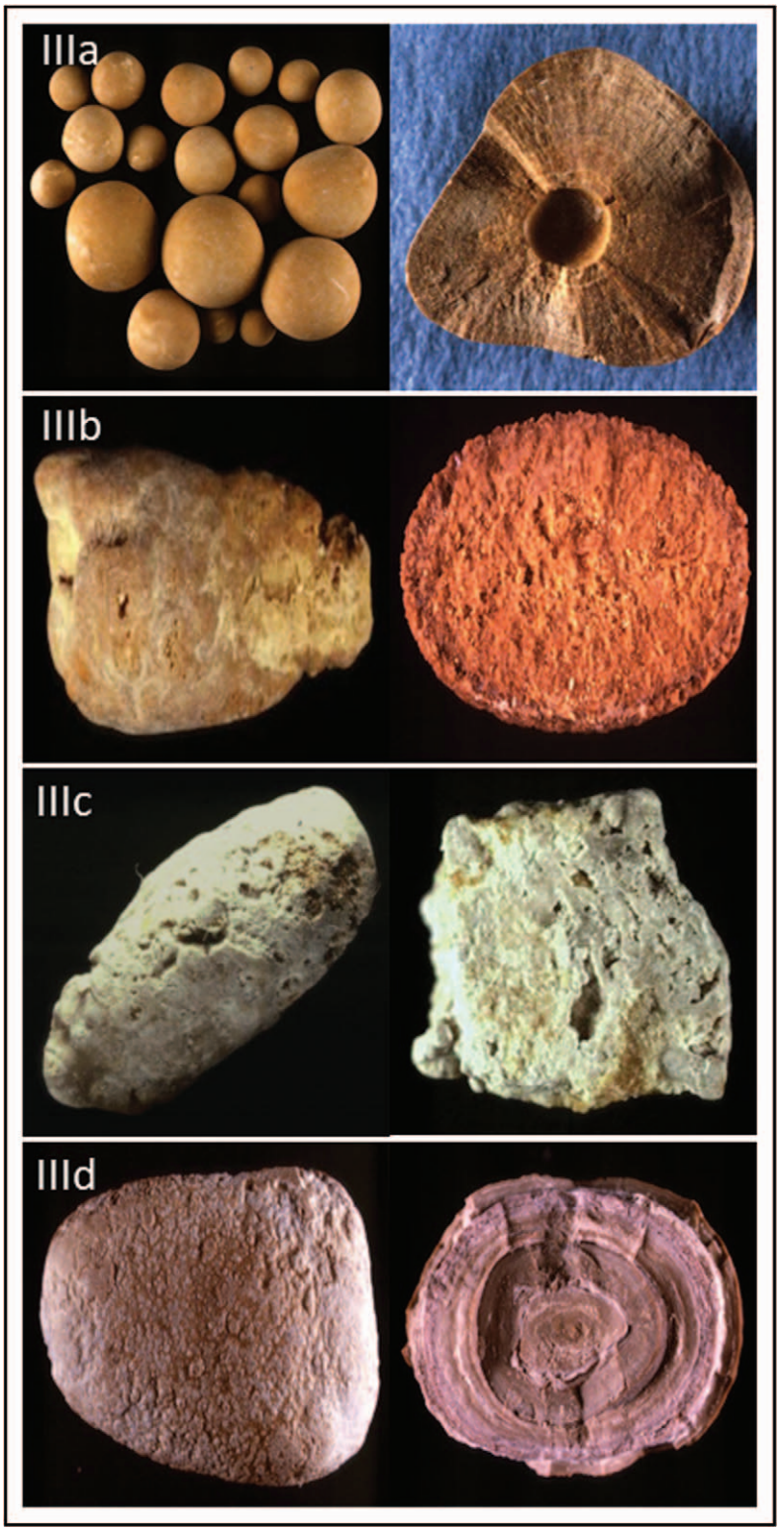

FIGURE 1. (*Continued*).

hyperparathyroidism (type IVd, or type IIa or IIb with IVa1). When smelling sulfide and seeing white bubbles during lithotripsy, diagnosis of cystinuria (type V) is made peroperatively [20].

Stones contain information of urinary environment at the times of formation and growth. Because less than 10% of stones are pure, it is important to identify the composition during lithotripsy when

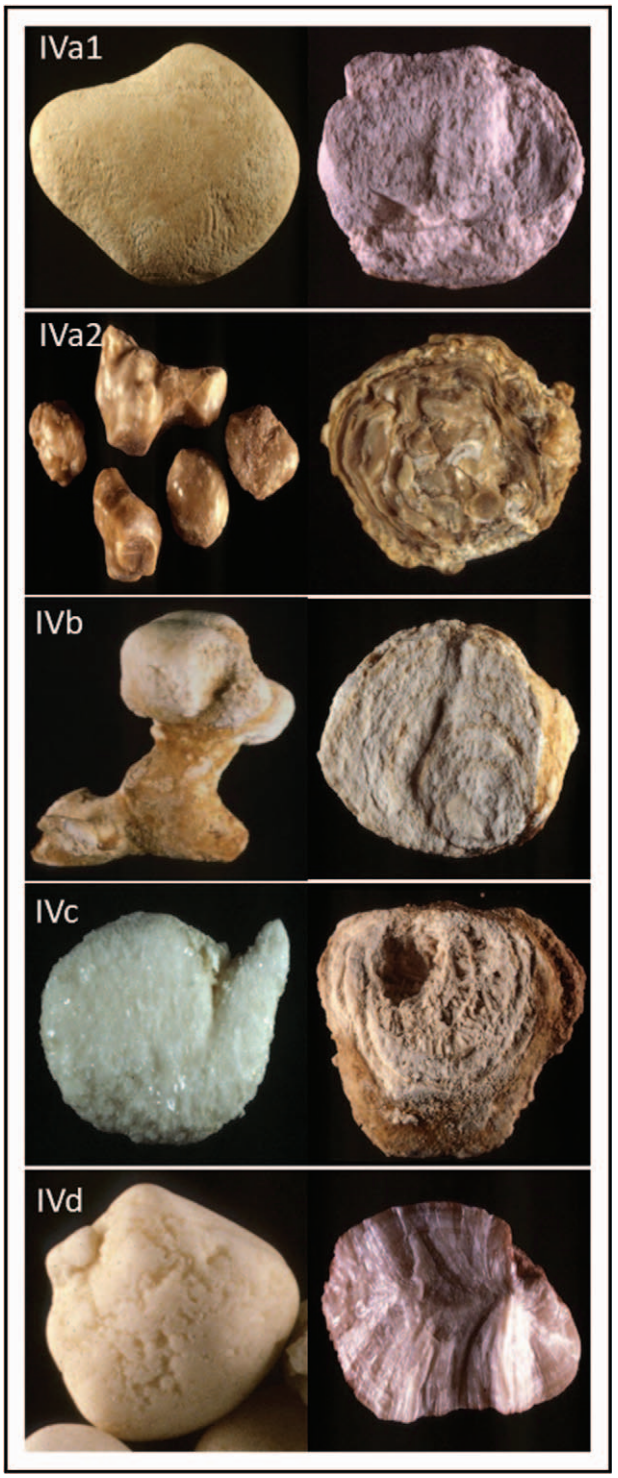

FIGURE 1. (*Continued*).

only a couple of fragments are sent for analysis. Frequent stone associations are Ia or Ib + IIa or IIb in case of intermittent hyperoxaluria and hypercalciuria, IIa or IIb + IVa1 in case of absorptive or resorptive (e.g. primary hyperparathyroidism, immobilization, hyperthyroidism) hypercalciuria, and Ia + IIIb in case of metabolic syndrome and/or type 2 diabetes with hyperoxaluria [20].

SUPPLEMENTARY EVALUATION

The aim of performing a 24-h urine collection and a fresh early morning urine sample is to detect changes in the urine that may be associated with stone formation. It is widely discussed whether these examinations should be part of a basic assessment or not [51]. Following AUA and EAU guidelines, clinicians should only perform 24-h urine collections in a selective group of stone formers [7,9]. In our opinion, a basic 24-h and a fresh early morning urinalysis should be considered in all stone formers for the reasons exposed hereafter.

Twenty-four-hour and fresh early morning urine collection

Following AUA guidelines, clinicians should perform one or two 24-h urine collections in high-risk or interested first-time stone formers and recurrent stone formers. High-risk stone formers are defined as those with a family history of stone disease, malabsorptive intestinal disease or intestinal resection, recurrent urinary tract infections, obesity or medical conditions predisposing to stones (e.g. gout, diabetes mellitus type 2, renal tubular acidosis type 1, primary hyperparathyroidism, sarcoidosis) and patients with a solitary kidney. Recurrent stone formers include patients with repeated stone episodes and those with multiple stones at initial presentation. Urine metabolic testing should consist at minimum of total volume, pH, creatinine, calcium, sodium, potassium, uric acid, oxalate and citrate. Testing potassium, urea and cystine is only recommended in specific cases [7].

Following EAU guidelines, only high-risk patients require a specific metabolic evaluation with two consecutive 24-h urine collections. This risk stratification is not only based on disease severity but also on stone types [9]. For calcium oxalate stones, urinalysis requires measurement of urine volume, pH, specific gravity, calcium, sodium, magnesium, uric acid, oxalate and citrate. For calcium phosphate stones, it includes volume, pH, specific gravity, calcium, phosphate and citrate. For uric acid and ammonium urate stones, urine volume, pH, specific gravity and uric acid level are recommended. For cystine stones, urine volume, pH, specific gravity and cystine should be measured. In case of struvite stones, only repeated urine pH measurements are recommended. The EAU guidelines state that this metabolic work-up should be ideally performed on a self-determined diet in an ambulatory

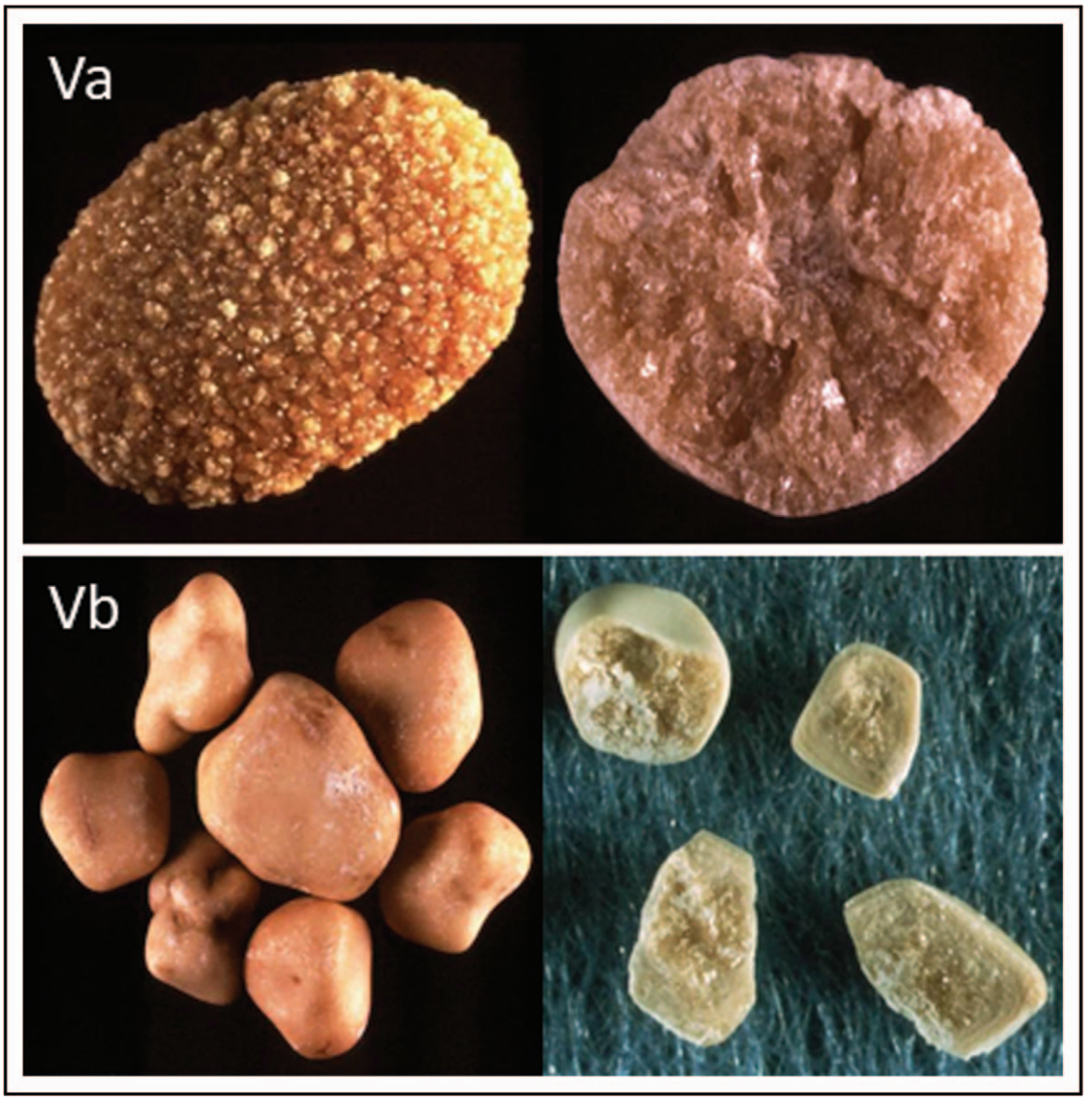

FIGURE 1. (*Continued*).

setting in a patient who is stone-free or at least 3 weeks after a urological intervention [8].

In our opinion, a basic 24-h urinalysis and a fresh early morning urine sample should be considered in all motivated stone formers to understand the lithogenic processes, underlying diseases, to propose individualized pharmacological and diet interventions, and to monitor them during follow-up [6,9,52,55–58]. Initially, this basic 24-h urinalysis should only include six parameters: total volume, creatinine (validation of adequate 24-h urine sampling), calcium, sodium (daily sodium intake), urea (daily protein intake) and uric acid (fructose and purine metabolism). Early morning urine should include pH and specific gravity. pH should be measured with a portable pH meter or a laboratory pH meter because they are more accurate compared to reagent strips readings [59▪]. These tests should be performed a couple of weeks after surgery or stone expulsion when the patient is on a self-determined diet under normal daily conditions. Performing a second collection as part of the initial evaluation may be of interest, because variations are intrinsic to patients' diet and activities.

For most first-time stone formers with type Ia, Ib, IIa, IIb, IIIa or IIIb stones, this basic 24-h and a fresh early morning urinalysis provide sufficient information to guide preventive measures and treatment. Other stone type formers require an extensive evaluation in most cases.

FIGURE 1. (*Continued*).

EXTENSIVE EVALUATION

An extensive patient-specific evaluation should be individually determined. It is based on patient's medical history (e.g. early onset of stone formation, stone recurrence, diseases or environmental factors associated with stone formation, genetically determined stone formation), physical examination (e.g. obesity, arterial hypertension), urine and blood analysis (e.g. underlying metabolic disorder), medical imaging examinations (e.g. multiple stones, anatomical abnormalities associated with stone formation, solitary kidney, nephrocalcinosis, medullary sponge kidney), stone analysis (e.g. drug-induced stone formation) and in case of stones of unknown composition.

Extensive urine and blood analysis

Depending on the results of abovementioned investigations, additional haematological parameters that should be analysed may be bicarbonate (e.g. metabolic acidosis), phosphate (e.g. renal phosphate wasting), magnesium (e.g. mutations in CLDN16 or CLDN16), PTH (e.g. hypercalcaemia and hypercalciuria), calcidiol and calcitriol (e.g. hypercalcaemia and hypercalciuria). When hypercalciuria cannot be

explained by dietary habits, a calcium load test with or without a bone densitometry to exclude osteopenia should be performed [60].

Twenty-four-hour urinalysis can be extended with oxalate (e.g. primary and enteric hyperoxaluria, nephrocalcinosis), citrate (e.g. renal tubular acidosis, medullary sponge kidney), phosphate (e.g. renal phosphate wasting, estimating protein and diary product intake) and cystine (cystinuria).

The study of crystalluria is a cheap and valuable tool for diagnosis and monitoring of acquired and congenital disorders associated with urolithiasis. It reflects different lithogenic factors (e.g. uric acids, urates, calcium oxalates, calcium phosphates), it may orient to rare diseases (e.g. deficiency of adenine phosphoribosyltransferase) or drug-related stones (e.g. amoxicillin, atazanavir, ceftriaxone, ciprofloxacin, sulfamethoxazole), and reflects the activity of stone diseases and the response to therapeutic measures (e.g. primary hyperoxaluria, cystinuria) [61]. Crystalluria examinations should be performed on fresh first-voided morning urine samples, because urine produced during the night is usually the most concentrated and therefore carries the highest risk of supersaturation and crystal formation [62].

FOLLOW-UP

After the initiation of dietary measures, medication or treatment of underlying diseases, the initial follow-up of stone patients should be individualized depending on the type of stones, stone growth or new stone formation, therapeutic tools and patient's motivation [51]. Depending on the underlying lithogenic factors, this can be performed using well selected above mentioned examinations. Monitoring these specific parameters allows the assessment of patient's compliance, dietary habits and response to medical therapy. This should be performed with a 24-h urine collection to assess response to dietary and/or medical therapy within 2–3 months after starting pharmacological prevention of stone recurrence following EAU guidelines and within 6 months following AUA guidelines. The latter guidelines state that patients on pharmacological therapy should undergo earlier period blood testing to assess for adverse events [7,8].

After the initial follow-up and once urinary parameters have been normalized, a 24-h urine collection should be performed annually or more frequently depending on stone activity following the AUA guidelines or, if necessary, following the EAU guidelines.

Repeating medical imaging (either by ultrasound, plain abdominal imaging or non-contrast-enhanced low-dose CT) to assess for stone growth or new stone formation should be based on stone activity. In case of stone recurrence, stone analysis should be repeated. Follow-up may be discontinued when patients remain stone-free for an extended period [7,8].

CONCLUSION

The AUA and EAU guidelines differ about how, when and how often a metabolic evaluation should be performed, because there is little published evidence on this issue. While stone analysis is a cornerstone for further diagnostic and management decisions according to the EAU guidelines, it is only a tool to direct preventive measures following the AUA guidelines. The latter guidelines are also less selective for a 24-h urine analysis. In contrast, the EAU guidelines recommend a stricter follow-up what we applaud. In our opinion, performing perioperative stone recognition and 24-h urine analysis should be supported to understand the lithogenic process which will guide patients during follow-up.

In conclusion, stratification of stone formers should be based on medical and lifestyle history, physical examination, basic urine and blood analysis, radiological examination and per and postoperative stone analysis. The latter is of utmost importance because it contains the metabolic history of the patient and defines the recurrence risk. In absence of risk factors, preventive individualized measures including appropriate drink intake, balanced diet and lifestyle advice are sufficient. In case of risk factors, an extended individualized metabolic evaluation should be performed to exclude underlying diseases and to start stone-specific recurrence prevention. Thereafter, the frequency of metabolic work-up and follow-up of stone formers should be tailored to the type of stone, severity of the disease, patient's comorbidities and medications.

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Conflicts of interest

There are no conflicts of interest.

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Papers of particular interest, published within the annual period of review, have been highlighted as:

- ■ of special interest
- ■■ of outstanding interest

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